IES LM-92 UV LED Measurements

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Abstract

UV LEDs often target applications where the total light dosage is precisely controlled. Designers that use UV LEDs rely on accurate irradiance data to ensure the LEDs in their products will deliver the correct dosage for the application.

The ANSI/IES LM-92 – Approved Method: Optical and Electrical Measurement of Ultraviolet LEDs, published last year, includes two new techniques for making measurements that promise better accuracy due to reduced junction heating.

This paper presents an experimental LM-92 UV-LED measurement system that implements the new DCP and M-DCP methods. This system makes high-accuracy irradiance measurements using an array spectrometer, a photodiode and a precision pulsed source/measure instrument. These instruments are controlled by Python software. For M-DCP measurements, a multi-slope integrating DMM is used.

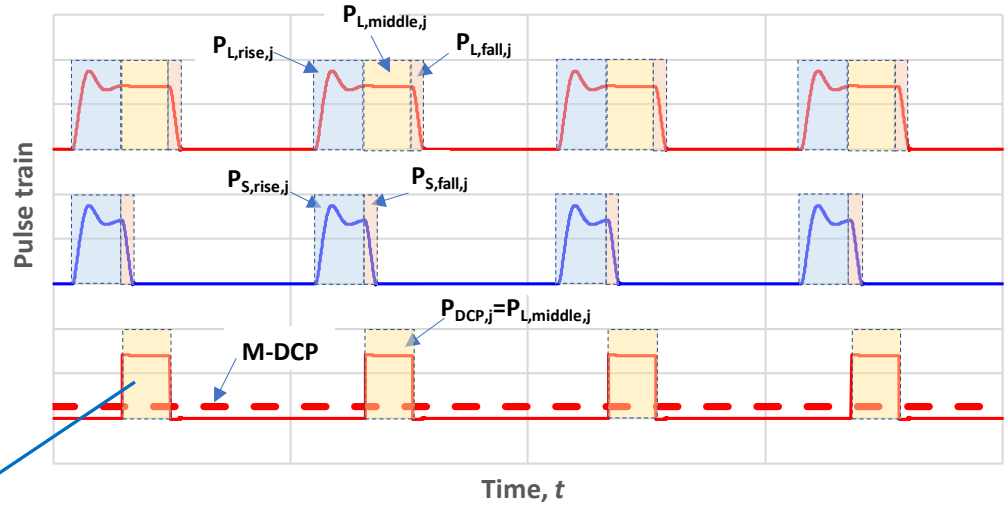
The system architecture is presented, and measurement results for the two methods for a typical high-power UV-C LED are discussed. Error sources are listed, along with recommended best practices for implementing similar optical measurement systems.

Background

- This research began as an effort to implement useable Python scripts for LM-92 measurements
- Work began in April, using a photodiode as a detector
- After the photodiode a CAS-140 visible spectrometer was added
- This paper discusses the third iteration which uses a Gigahertz-Optik UV spectrometer

LM-92's Differential Continuous Pulse (DCP) method reduces CP error sources by about two orders of magnitude

DCP takes the difference of two CP measurements – one with long pulses (e.g. 20µs) and one with short pulses (e.g.10µs)



Light remaining after subtraction is from middle, flat portion of long pulse, amplitude, timing, and dark current errors subtract out

The LM-92 Standard Requires 3 Test Methods

For Test Currents:	Method
Above 10% of nominal	DCP (10/20 us) 1% Duty
Between 1% and 10% of nominal	DCP (25/50 us) 1% Duty
Below 1% of nominal	Single Pulse

M-DCP can be used instead of DCP And DC can be used instead of Single Pulse

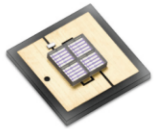
DUT for Experiment: Luminus UV-C LED

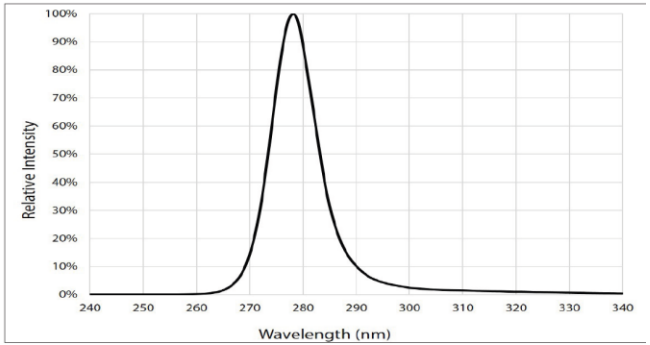
- High power UV-C LED
- 6-8V, 2A part
- 270-280 nm
- Mounted on star boards

LUMINUS

XFM-5050-UV
Product Datasheet

XFM-5050-UV
4-chip Surface Mount
UVC LED





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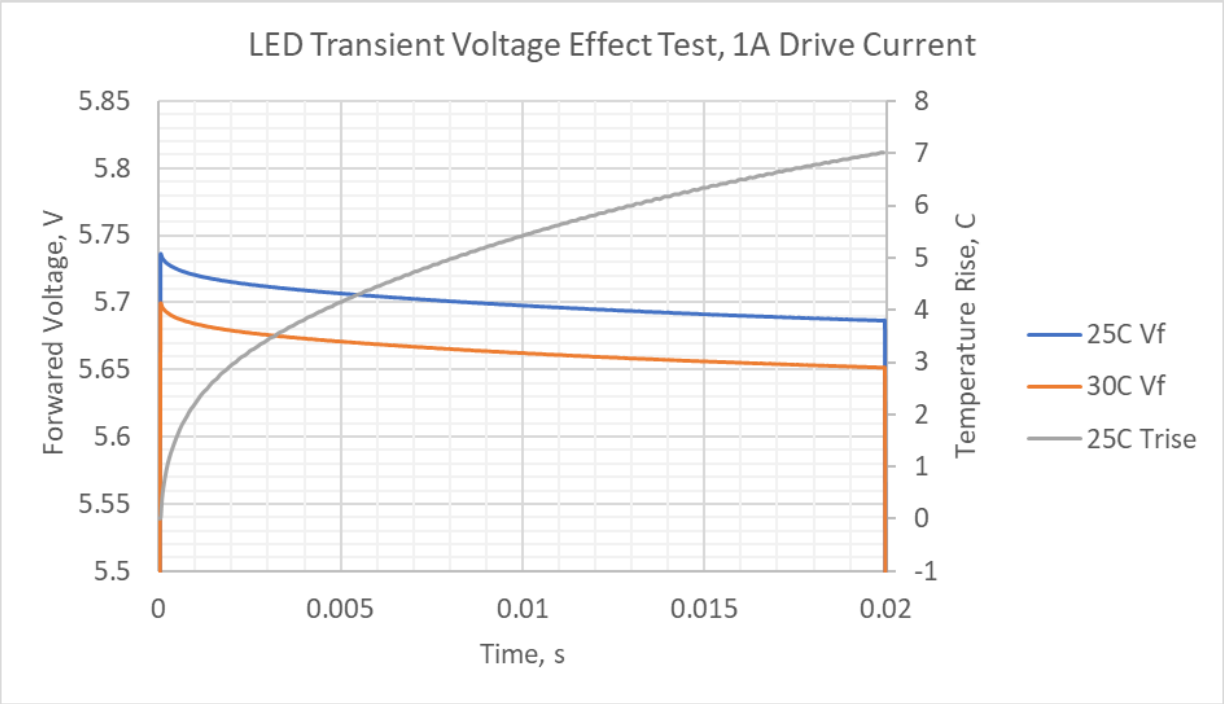
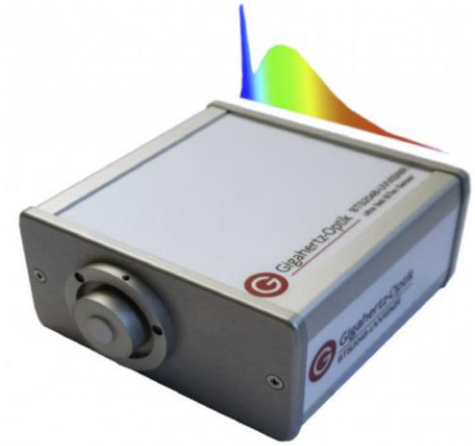
UV DUT Showed No Transient Voltage Effect

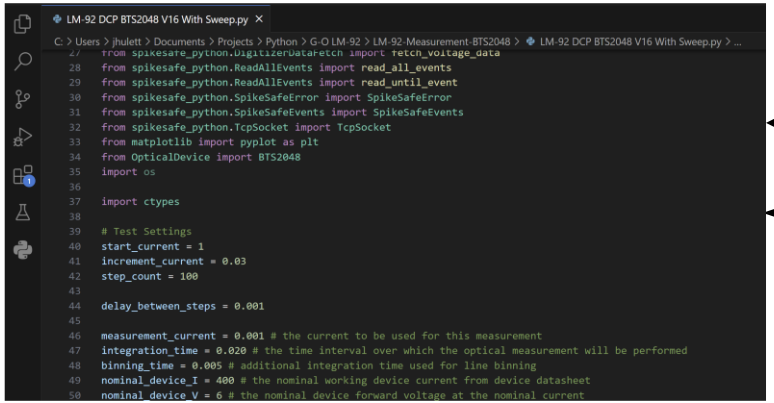


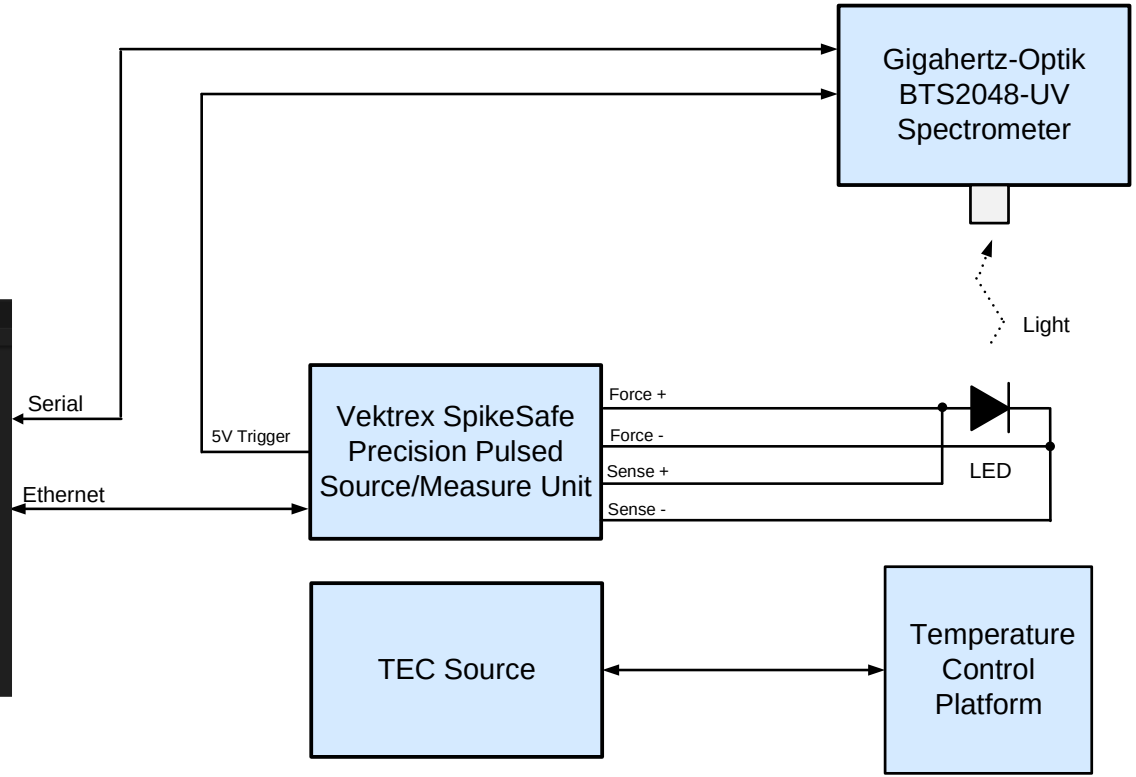
Key Instruments Used



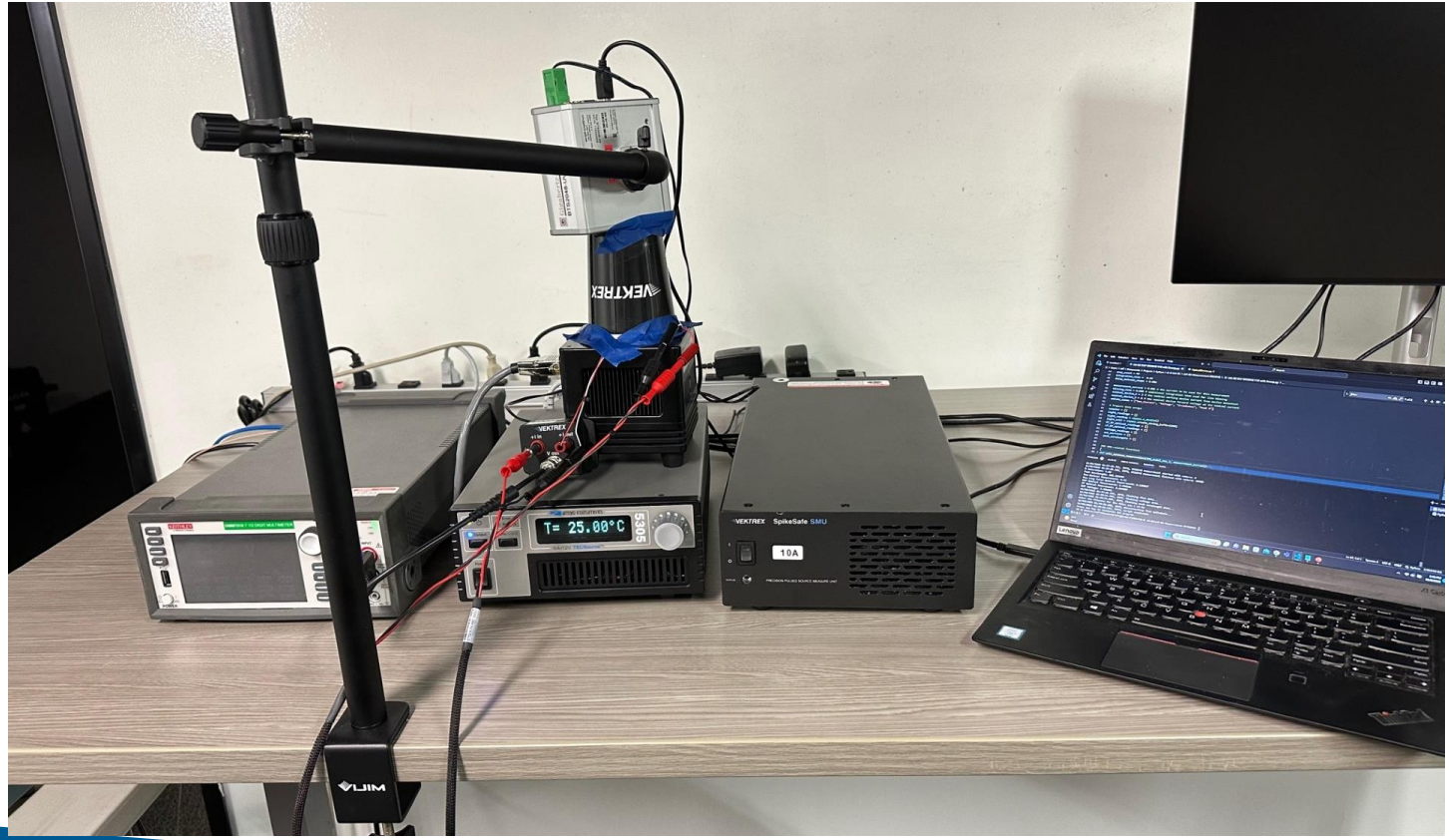
Test System Block Diagram – UV LED (DCP and Single Pulse)

Test Application:
Python Program



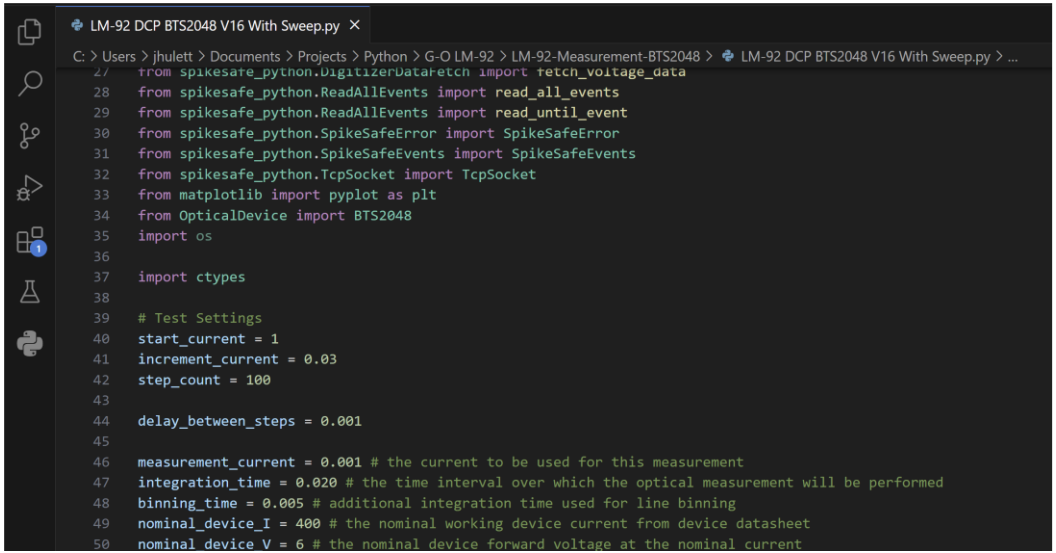


Test System Photo



Python Test Program

- Developed in collaboration with Gigahertz-Optik
- Produces L-I-V sweep graphs
- Automatically chooses the correct LM-92 measurement method
- Settable integration time, max and min current, etc.
- Scaler subtraction (long pulse used for peak wavelength)



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UV LED Tests Using Spectroradiometer

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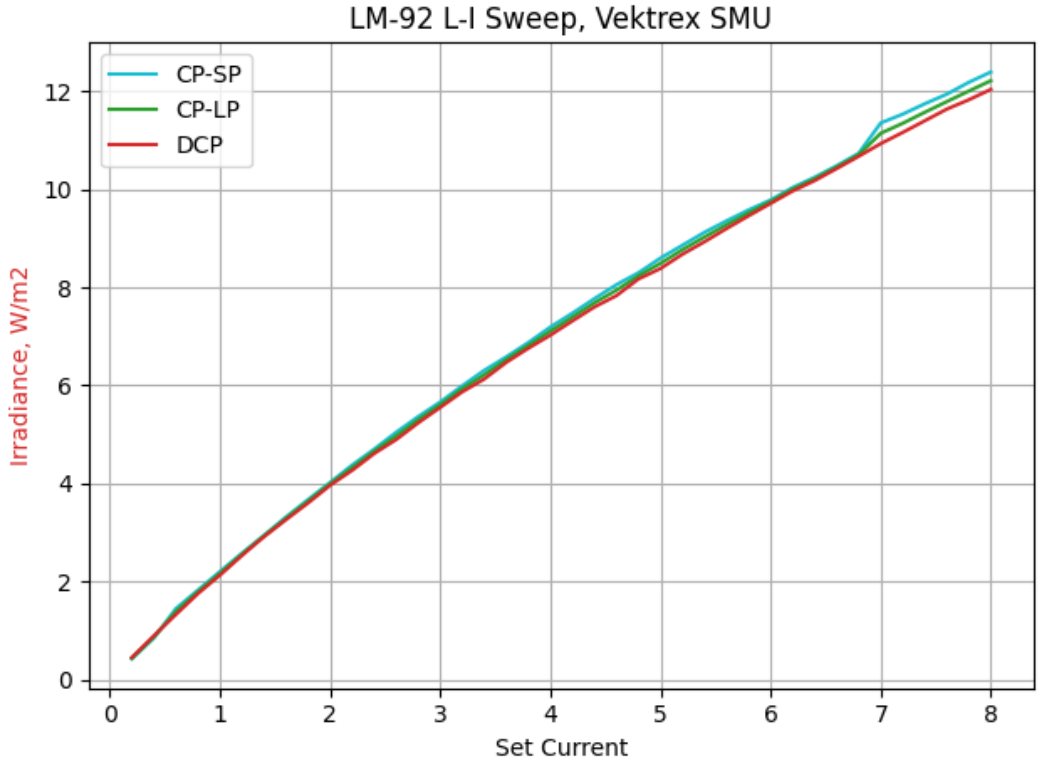
Test 1: UV Device LM-92 Irradiance



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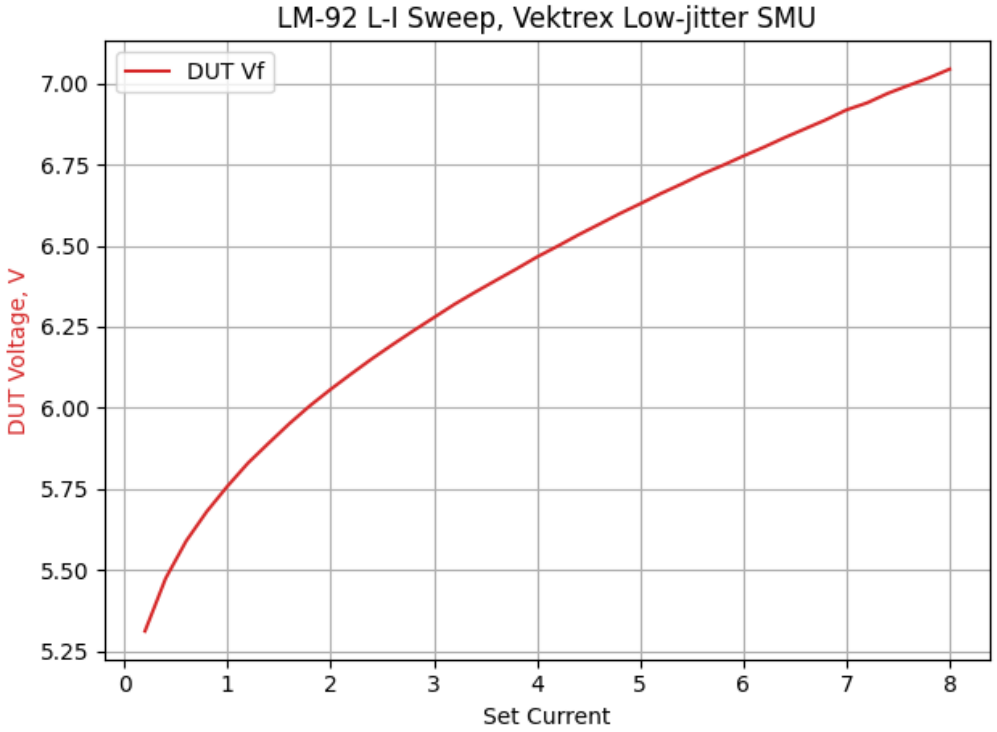
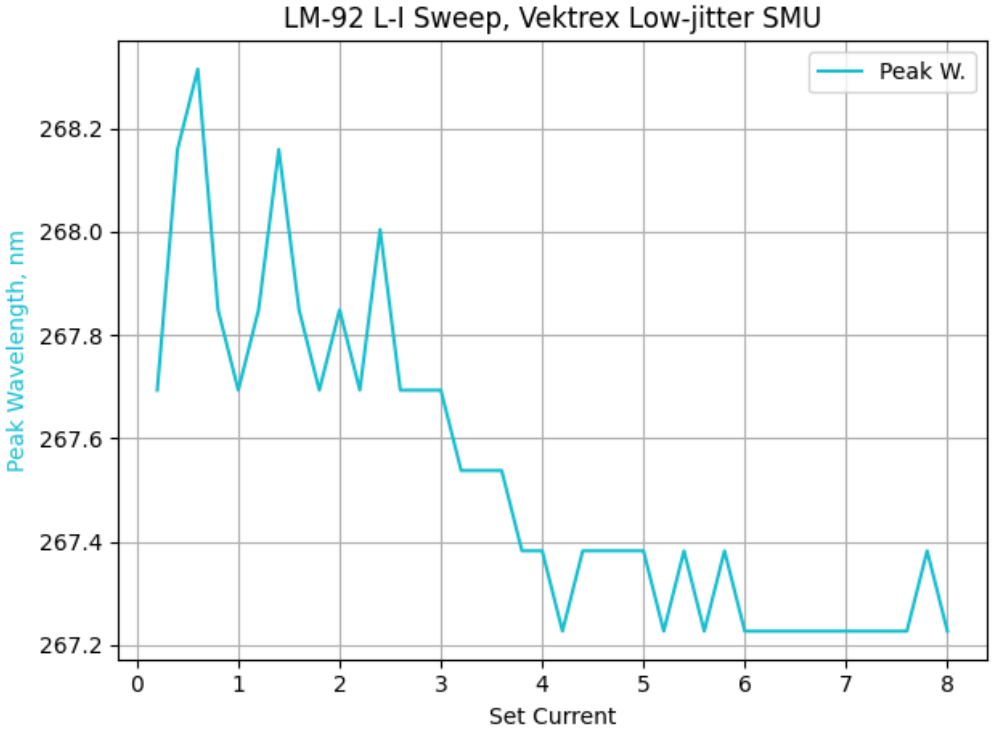
Test 1: UV Device LM-92 Vf



Test : UV Device LM-92 Peak Wavelength



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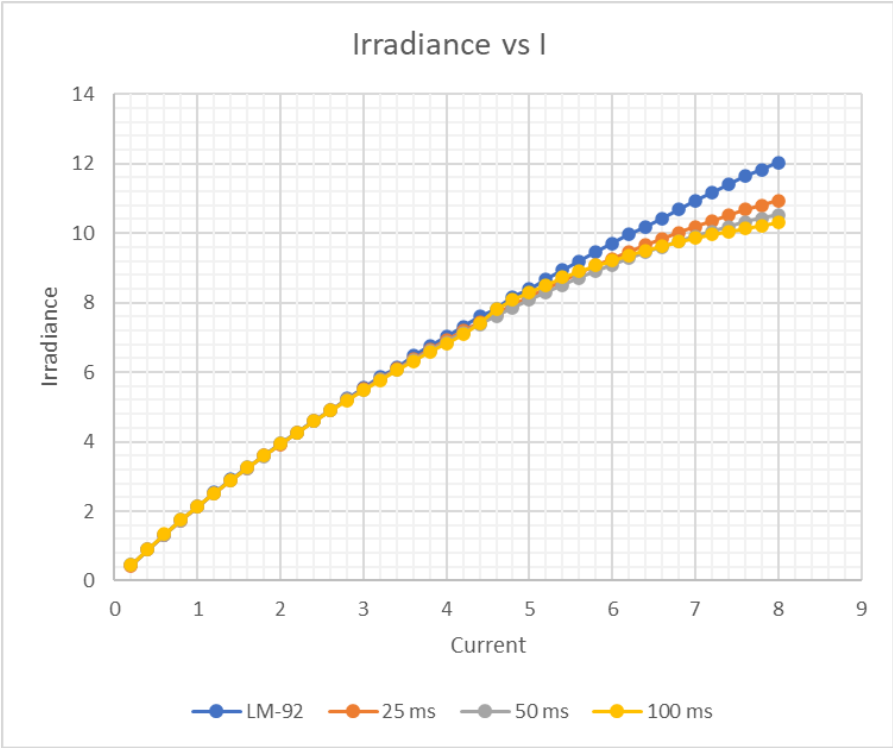
LM-92 and Long Pulse Compared, Irradiance



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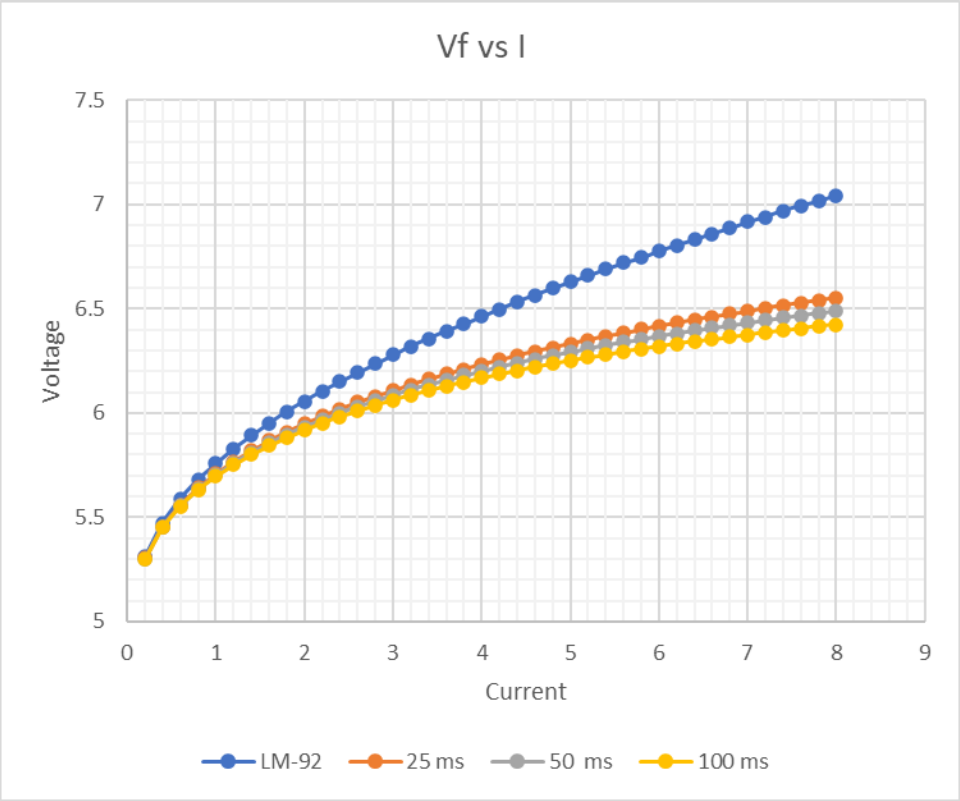
LM-92 and Long Pulse Compared, Vf



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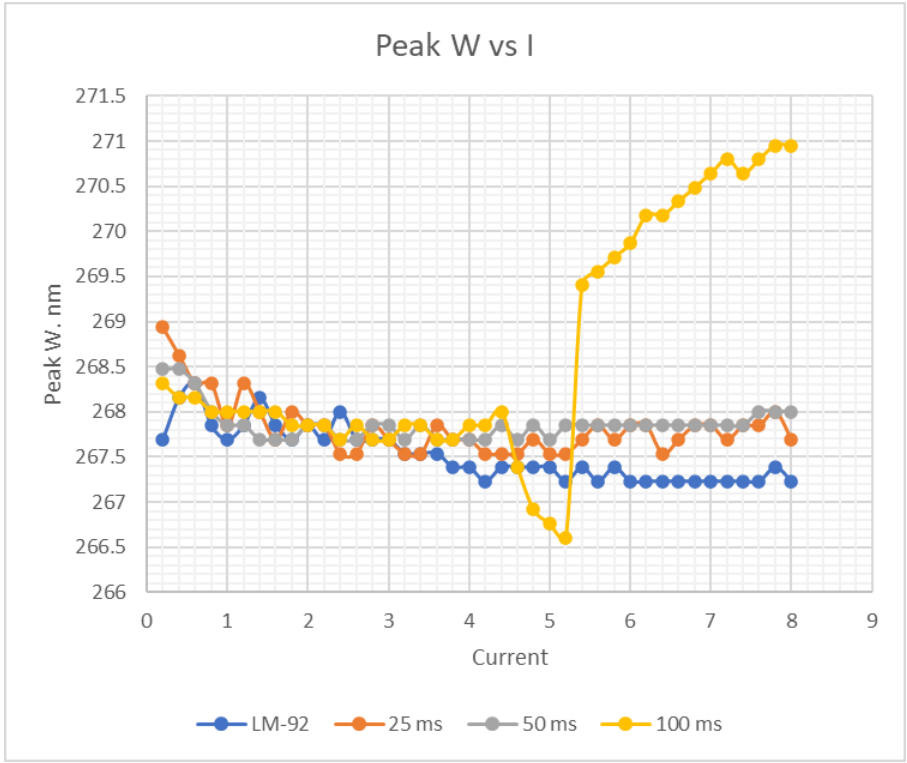
LM-92 and Long Pulse Compared, Peak W.

Note overall declining peak wavelength as current increases. Long Pulse measurements produce heating that counteracts this, resulting in a flat curve.



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Error Sources – UV measurements

- Current Source:
  - Good waveform shape,
  - Pulse accuracy quite good, < 0.5 us error
  - Rise and fall around 1 us, low rise/fall error
- Spectroradiometer
  - Integration time parameter not fully settable due to Python programming issue. Not yet debugged. This caused noise for the 1% DCP measurements. To overcome this the Python was adjusted to use 10% DCP for the 10/20 us case
- Temperature
  - Temperature control platform maintained MCPCB temperature at 25C. Low thermal resistance in MCPCB board resulted in low heating

Visible LED Testing Using Photodiode & Multislope Integrating DMM

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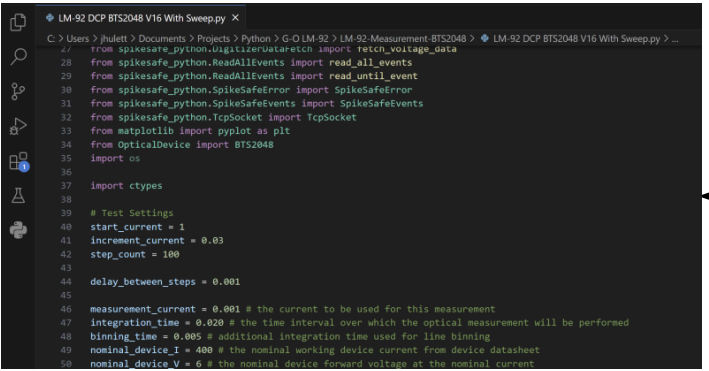
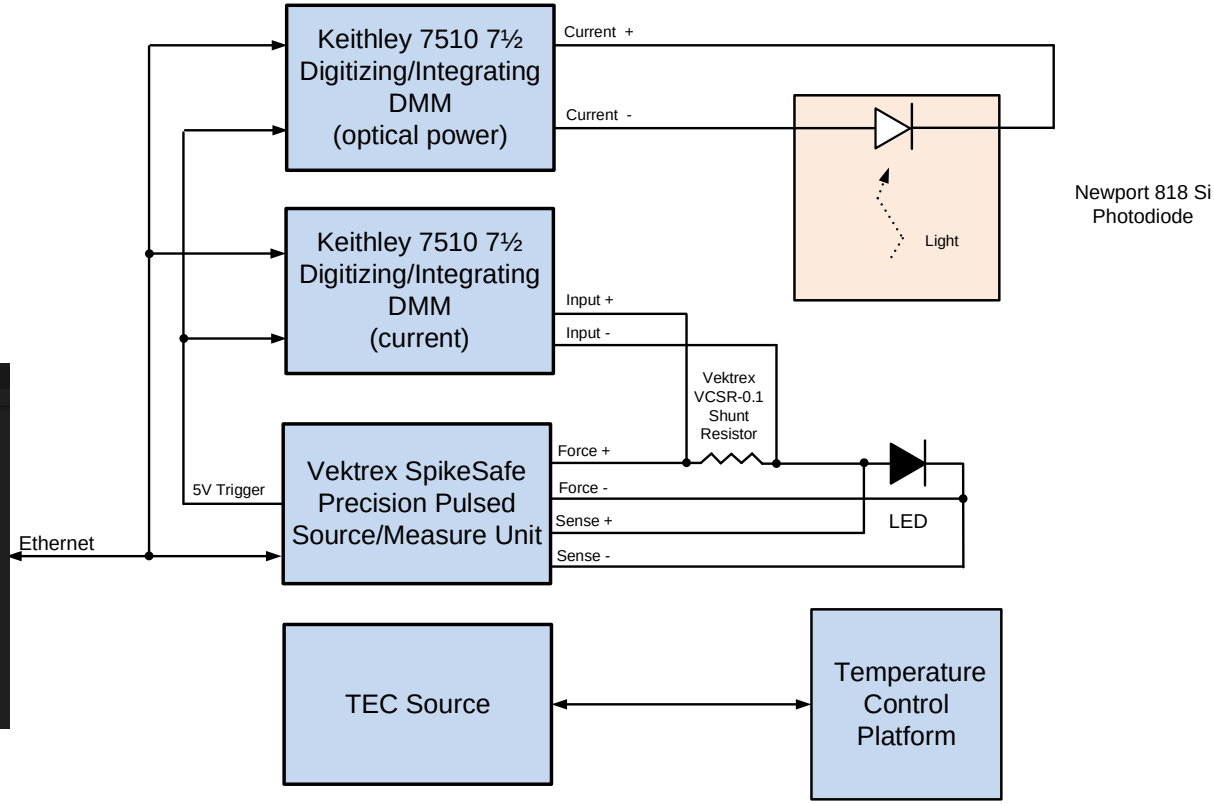
Test System Block Diagram – Visible LED

Test Application:
Python Program

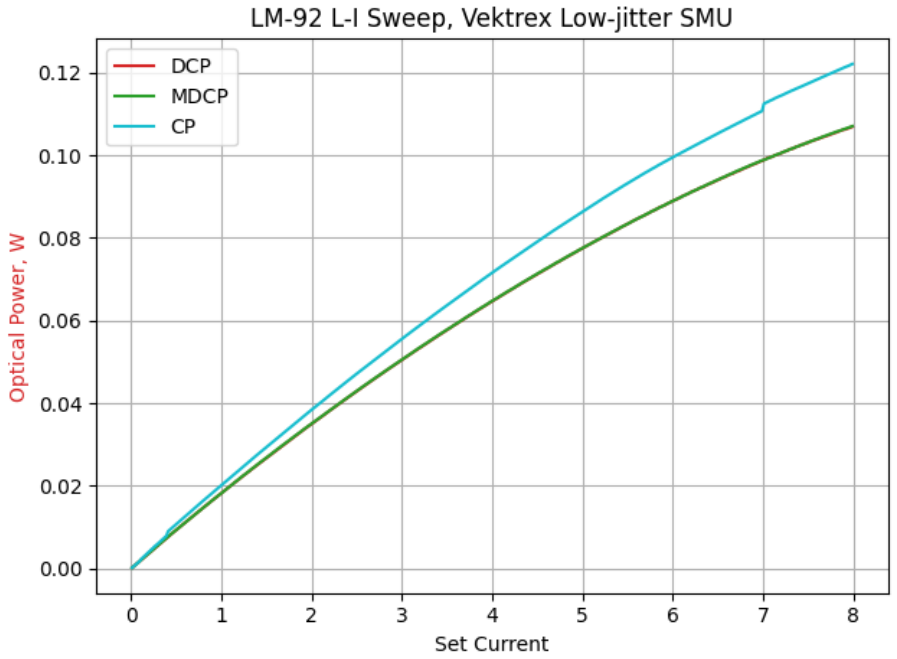




Test 3: Vektrex SMU L-I-V Sweep

CP measurement is greater due to rise and fall error.

M-DCP produces same curve as DCP because Vektrex SMU has little jitter.



What is jitter and why is it so important?

- Jitter is a variation in the pulse rise and fall position, similar to tempo variations in music

- A 1 us variation in a 10 us pulse width is 10% current error.

SMU	Jitter	RSS DCP Error
SMU 1 – Vektrex	10 ns	0.11%
SMU 2 – Bench	110 ns	1.47%
SMU 3 – PXI	1000 ns	11.2%

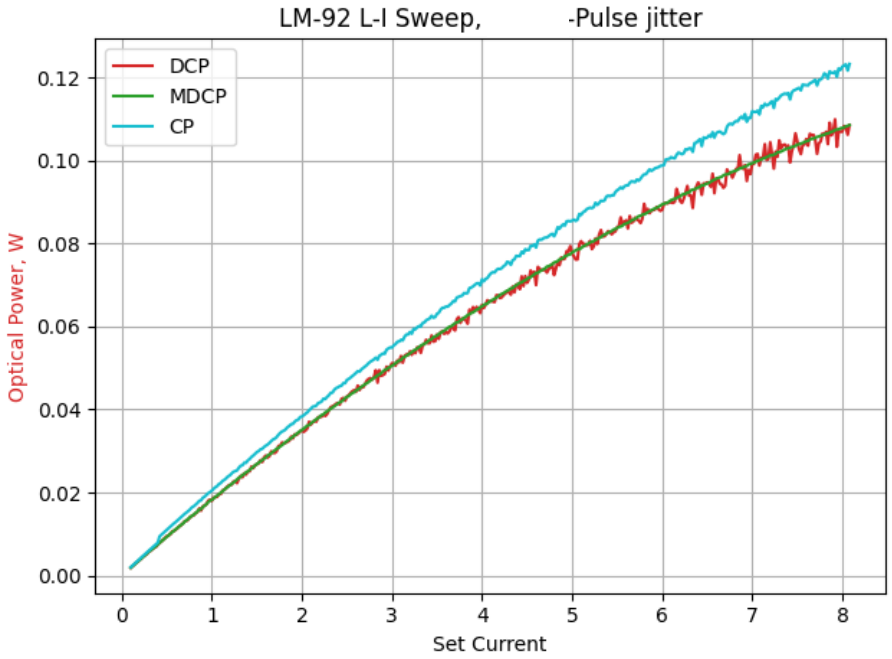
Test 3: SMU 1 (rack/bench) (Simulated) L-I-V Sweep

Pulse Width Programming Minimum	10 µs.
Pulse Width Programming Accuracy	±200 ns.
Pulse Width Jitter	110 ns (typical).
Pulse Period Jitter	2 µs (typical).

CP measurement has noise due to SMU pulse jitter.

DCP has higher noise because two measurements are involved (RSS higher)

M-DCP removed jitter noise by measuring the true average current for each measurement



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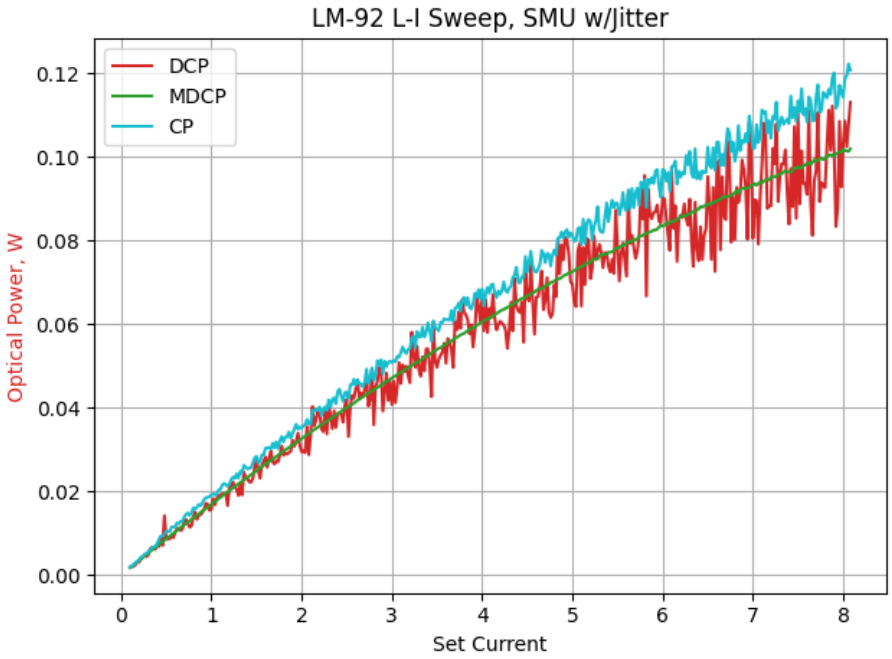
Test 4: SMU 3 PXI (Simulated) L-I-V Sweep

Pulse on time or off time programming resolution	100 ns, nomina
Pulse on time or off time programming accuracy	±5 µs, nominal
Pulse on time or off time jitter	1 µs, nominal

On-Time jitter of 1 us causes significant variation

Again M-DCP removed jitter noise by measuring the true average current for each measurement



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Error Sources – visible measurements

- SMU 1 Vektrex Current Source:
  - Good waveform shape,
  - Pulse accuracy quite good, < 0.5 us error
  - Rise and fall <2 us
  - Low jitter (typically < 10 ns)
- SMU 2, SMU 3 higher jitter, lower pulse width accuracy

- Photodiode
  - Rough calibration was performed by comparing photodiode power to CAS-140 measurement, but no uncertainty analysis was done. Measurements should be considered relative.

- Temperature
  - Temperature control platform maintained MCPCB temperature at 25C. Low thermal resistance in MCPCB board resulted in low heating

Findings

- The Python scripts greatly simplify LM-92 measurements. An L-I-V curve can typically be generated in 2-3 minutes.
- LM-92's 3 methods allow very low current measurement data to be easily merged with high current data. This is useful for creating multi-decade plots
- M-DCP is only necessary if using a high jitter SMU
- The LM-92 standard could be tweaked in a few areas to make it simpler to make measurements
  - Rules for voltage measurements should be clarifies
  - More flexibility for pulse width and duty cycle to accommodate some instrument channels

Acknowledgements

- I would like to thank the following parties:
- Vektrex, for allowing me to do this interesting (and challenging) research
- Gigahertz-Optik for supplying a great UV spectrometer
- Luminus Devices for supplying rugged and reliable test samples

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Thank you